DOCUMENT RESUME

ED 460 933 SP 036 192

AUTHOR Manouchehri, Azita
TITLE Theory and Practice: Implications for Mathematics Teacher Education Programs.
INSTITUTION Association of Independent Liberal Arts Colleges for Teacher Education.
PUB DATE 1996-01-00
NOTE 22p.; Paper presented at the Annual National Forum of the Association of Independent Liberal Arts Colleges for Teacher Education (7th, St. Louis, MO, June 2-4, 1995).
PUB TYPE Information Analyses (070) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Constructivism (Learning); Educational Change; *Educational Trends; Elementary Secondary Education; Higher Education; Knowledge Base for Teaching; Literature Reviews; *Mathematics Education; *Mathematics Teachers; Pedagogical Content Knowledge; *Preservice Teacher Education; Teacher Attitudes; *Teacher Education Curriculum
IDENTIFIERS *Mathematics Education Research; *Reform Efforts; Subject Content Knowledge

ABSTRACT

This paper reviews current trends in the training of teachers, particularly in the areas of content knowledge and pedagogical content knowledge, pedagogical reasoning, training, and beliefs. Content knowledge consists of the key facts, concepts, principles, and explanatory framework in the discipline, in this case mathematics. Pedagogical content knowledge or subject-specific pedagogical knowledge is defined as knowledge of students and learning, knowledge of curriculum and school context, and knowledge of teaching. Pedagogical reasoning is the process of transforming content knowledge into forms that are pedagogically powerful and adaptive to particular groups of students. The discussion of training includes a 15-point list of essential training principles as gleaned from a synthesis of the research. Beliefs are considered the attitudes and assumptions of entering preservice teachers, beginning teachers, and experienced teachers, and the power of these beliefs to effect change in education. As teacher educators think about the reform movement, especially in the areas discussed, they need to ask themselves whether they and their programs have realized the importance of nurturing these qualities and standards in their own practice. They need to ask what teacher education programs have done to prepare teachers to be active participants in learning and teaching. In conclusion, the paper proposes that the need for a theory of reform in the education of teachers is urgent. (Contains 52 references.) (JB)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 460 933

Theory and Practice: Implications for Mathematics Teacher Education Programs

Azita Manouchehri
Mathematics Education
Maryville University
azita@maryville.edu

Paper Prepared for the Sixth National Forum
Association of Independent Liberal Arts Colleges for Teacher Education
June 1995
St. Louis, Missouri

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
T. Warren
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

BEST COPY AVAILABLE

SP036192

Teacher is the most important agent in the whole educational enterprise.

A. Bishop, 1985, p. 24

Introduction

The past 30 years has been the era of change of themes in research on learning and teaching (Kilpatrick, 1977). Attention seems to have turned from what is taught and learned to where, when, and how teaching and learning occur. In general, there appears to have been a tidal shift in research from the content of teaching and learning to the context in which they take place. Parallel to that shift has been another in the view taken of knowledge and its formation. The school curriculum is increasingly being seen as less a collection of topics than a set of experiences. Learning is viewed as active construction rather than passive absorption, teaching as facilitation rather than transmission. A third shift has occurred in the view taken of research itself and consequently some of the methods used in doing research. As the empirical-analytic tradition has begun to lose favor in mathematics education as well as education in general, researchers have sought other alternatives. Increasingly attractive, especially to researchers in North America, is the view of research as the interpretive understanding (Eisenhart, 1988).

Also, research on teaching has blossomed during this period, and whereas the teacher used to be viewed as a nuisance in theory and research on learning, an intervening variable whose influence had to be controlled statistically if not otherwise, increased attention is being paid to the teacher's key role in influencing classroom learning (Bauersfeld, 1978). In fact, the teacher increasingly is viewed as collaborator, rather than experimental subject or irrelevant object, in the enterprise of building and validating theory (Kilpatrick, 1977).

What this shift represents, is simply a reform in the essence of educational research and the whole of education. This shift has been partially due to the societal concern with educational outcomes, the need for better educational designs, and urgency of the collaboration of schools with the research community.

Along with the "paradigm shift" in educational research, school curriculum also has also been experiencing a variety of reforms. The shift from the traditional models of teaching to more humanistic and progressive frameworks, and the battle over directing teaching towards understanding, and learning in terms of connection-making has been an ongoing process for decades. In this process, we have witnessed the birth and growth of new movements with the goal of promoting "meaning and meaning making," increasing "critical thinking," and "problem solving" skills.

In the area of mathematics in particular, The Agenda for Action (1980), opened a new dimension to the way many educators and teachers viewed their teaching and their role in the socio-

political structure of society. Some researchers view the turning point in the tug and pull of the school mathematics curriculum to be the Agenda for Action of the NCTM (Wilson & Kilpatrick, 1984). This report, which reflected an input by mathematics teachers, presented recommendations for school mathematics in the 1980s. The recommendations in the Agenda called for an emphasis on problem solving and applications, a re-examination of basic skills, incorporating calculators, computers, and other technology into the mathematics curriculum and mathematics teaching, and more mathematics for all students. As a response to the call of the Agenda, in 1986, the Board of Directors of the National Council of Teachers of Mathematics established the Commission on Standards for School Mathematics as one means to help improve the quality of school mathematics (NCTM, 1989). The product of the commission's efforts was the Curriculum and Evaluation Standards for School Mathematics (1989), which established a framework to guide reform in school mathematics. This document, along with the Professional Teaching Standards (1991), presented a vision of school mathematics curriculum, of evaluation, and of teaching that was(is) different from what most teachers experienced in their mathematical education and what was(is) found in most textbooks.

The corollary to the comments of the Agenda and Standards is that if the mathematics curriculum changes as proposed, the need for competente teachers will become more desperate. More teachers will be needed, they will need more and better training, and many teachers in the field will need advanced training, and perhaps, retraining (Wilson & Kilpatrick, 1984). That is, "teaching for better mathematics" (Begel, 1970) demands better teaching of mathematics.

Although the National Council of Teachers of Mathematics has developed guides for the content and pedagogy, both sets of standards provide the direction, but not the mechanism, for reform in school mathematics. This notion has been voiced by a number of mathematics education researchers. Neither one of the NCTM documents is well grounded in systematic research, although both are widely accepted as guidelines representing the mathematics education community's 'best thinking' on these topics (Brown and Borko, 1992, p. 235). In reality unless a 'mechanism' for reform is found in mathematics teacher education, even current guidance will not make an impact on the teaching of mathematics. This 'mechanism' can not but to take into account the findings, as well as the recommendations of the research in areas of learning and teaching mathematics, and mathematics teacher training. This need was recognized by Cooney and Brown (1985) as they argued that,

> Ultimately a theory or theories in mathematics education must provide a basis for understanding how the teaching and learning of mathematics can be improved, for otherwise the search for theory is an empty enterprise...We argue that ...the implications of theory should have potential for

> practical applications...Therefore attention must be paid to the context in which learning and teaching occurs (p. 15).

Bausersfeld (1978) voiced a similar sentiment when he proposed:

> We never escape either from the hermeneutic circle or from the need for the theoretical orientation (p. 42).

In trying to develop a guiding theory one needs to keep in mind that the test of a good theory is whether it can guide practice. In reverse, good practice is based on theory. Theory, as defined by Gage (1963), is the knowledge gained by research and experience that is generalizable and whereby potential users can make informed estimates of the probable effects and the effectiveness of practices. Good theories are workable for practitioners, make sense, and can be applied to the classroom, and are generalizable to a great number of real situations. They involve principles and propositions that can be generalized to many situations.

In reviewing the available research[1] on mathematics teacher education, five areas of recommendations towards the mechanism of reform in training mathematics teachers have been examined. These aspects are: content knowledge; pedagogical content knowledge encompassing pedagogical reasoning; beliefs; and training. In what follows an account of research on each areas is offered. Furthermore, implications of that theory for the practice of teacher education programs, as well as an examination of the current practice is presented.

Content Knowledge

Content knowledge consists of an understanding of the key facts, concepts, principles and explanatory frameworks in the discipline, as well as the rules of evidence and proof within the discipline (Shulman & Grossman, 1988). According to Ball (1990), subject matter knowledge should be a central focus of teacher education programs. Polya used a mix of subject matter and methods which was roughly a 9:1 (Kilpatrick, 1987), indicating the importance he placed on subject matter knowledge. Ball (1988) contends that to teach mathematics effectively, individuals must have knowledge of mathematics characterized by an explicit conceptual understanding of the principles and meaning underlying mathematical topics, rules, and definitions.

As described by Cooney (1994), although no firm evidence can be cited that knowledge of mathematics is related to effective teaching, it is difficult to imagine a rational argument that knowledge of mathematics should not be integral component of a mathematics teacher education program" (p. 11). Brown and Borko (1992) describe several studies which suggest that an increase in subject matter knowledge for preparing mathematics teachers is essential. At the

secondary level, no research has been reported on teachers' knowledge of mathematics beyond defining mathematical knowledge in terms of courses taken at the college level (Cooney, 1994). Furthermore, it has been suggested that although mathematics education majors take courses in both mathematics and mathematics education, conceptual understanding of the content is typically not stressed, and even when a course focuses on concepts, students regularly do not make conceptual understanding explicit enough to challenge previous algorithmic constructs of the mathematics (Borko, et. al., 1992).

In a recent study on three preservice secondary school mathematics teachers' assessment practices, it was reported that the procedures used in classroom (as well as the results) by the student teachers was stronlgy influenced by whether their knowledge of mathematics was conceptually or instrumentally based (Enderson, 1995).

Pedagogical Content Knowledge

Subject matter knowledge alone is not necessary for the work of teachers. Teachers need to possess subject matter knowledge that differs from the knowledge of experts on the subject matter (Shulman, 1986). They need knowledge of the subject, which is supplemented with knowledge of students and of learning, knowledge of curriculum and school context, and knowledge of teaching. Shulman (1986) called this specialized body of knowledge for teachers "pedagogical content knowledge."

> Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations- in a word, the way of formulating the subject that make it comprehensible to others. Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics difficult; the conceptions and pre-conceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (p. 9-10).

Pedagogical content knowledge or subject-specific pedagogical knowledge consists of how to represent specific topics and issues in ways that are appropriate to the diverse abilities and interests of learners (Borko, et. al., 1992, p. 196). That is, as Grossman (1985) so eloquently described it:

> If teachers are to guide students in their journey in to unfamiliar territories, they will need to know the terrain well. Both knowledge of the content and knowledge of the best way to teach that content students help teachers construct meaningful representations, representations that reflect

> both the nature of the subject matter and the realities of student's prior knowledge and skills. Preparing teachers to teach content means first engaging them in their own explorations of the territory and helping them to construct their own conceptual understanding of the materials. Teachers also need pedagogical maps of content, the understanding of the subject matter from an explicitly pedagogical perspective that enables teachers to track students' misunderstandings and guide them toward new conceptions (p. 213).

Polya described pedagogical content knowledge as "know-how." "Mathematical know-how is primarily the ability to formulate, solve, and critically reflect on problems" (Kilpatrick, 1987, p. 87). Brown and Borko (1992) contend from their survey of research that the pedagogical content knowledge, the one domain of knowledge unique to the teaching profession, is relatively underdeveloped in novice teachers. Implications from research suggests that methods courses should make pedagogical content knowledge a central priority (Brown and Borko, 1992).

Historically theories of learning have guided and directed the practice of teachers. Consequently, the majority of the energy of the teacher training has been focused on familiarizing preservice and inservice teachers with current theories of learning in hopes of increasing their sensitivity to such theories in their practice. However, one should not expect learning theories to dictate to education. Over three decades ago Gage (1963) contended that the theories of teaching should be developed which would be compatible with learning theory and other fundamental theories. He argued that one can not necessarily know how to teach, even if one has a reasonably comprehensive theory of learning. He used an agricultural analogy in which he pointed out that farmers need to know something about how plants grow, the way they depend on soil, water and sunlight, but the farmer must also know something about the process of farming. Similarly, teachers need to know how children learn and what relevance motivation, readiness, reinforcement and other psychological processes have for learning; but they specially need to know more about the teaching-learning process in practical situation.

> Too much of educational psychology makes the teacher infer what he needs to do from what he is told about learners and learning. Theories of teaching would make it explicit how teachers behave, why they behave as they do, and with what effect ? Hence, theories of teaching need to be developed alongside, on a more equal basis with, rather than by inference from theories of learning" (Gage, 1963, p.133).

Pedagogical Reasoning

Brown and Borko (1992) define pedagogical reasoning as the process of transforming content knowledge into forms that are pedagogicaly powerful and adaptive to particular groups of

students-- making the transition from a personal orientation to a discipline to thinking about how to organize and represent the content of the discipline to facilitate student understanding (p. 221). Feiman-Nemser and colleagues (1986) identify the transition to pedagogical reasoning as a major component of learning to teach, yet found that preservice teachers find it difficult to make the transition. They recommend that teacher educators take an active role in guiding preservice teachers' pedagogical reasoning by demonstrating teacher actions and decisions. Fuller and Brown (1975) describe the transition to pedagogical reasoning as going through four stages: preteaching concerns, self-concerns, tasks concerns, and pupil concerns. They argue that teachers will not develop concerns about pupils or their understandings until they have resolved concerns about their own survival and teaching situation. In the case study by Borko, at. al, (1992), the student teacher focused on classroom management. Her use of activities and applications in the class was not to facilitate student understanding, but to maintain student interest and avoid management problems.

The literature suggests that teacher education needs to focus on the actual challenges that teachers will face in the classroom in order to develop pedagogical reasoning (Lanier & Little, 1986). Teacher education should also "enculture" preservice teachers in a standard pedagogical method such as described by the NCTM documents by having university programs, cooperating teachers for student teaching, mentors for beginning teachers supporting those documents.

> Unless novice teachers experience good mathematics as students, see it modeled by teachers they respect, and are situated in a culture of teaching that accepts and practices good teaching, it will be difficult for them to implement and maintain good teaching in their classrooms (Brown & Borko, 1992, p. 227).

The development of such pedagogical reasoning relies heavily on the teachers' awareness of the reality that theories about teaching may not provide specific answers or quick solutions to problems. And that, teachers need to examine various teaching principles and practices based on theory. According to Stallings and Stipek (1986), teachers should try different approaches for different subjects, and ultimately develop their own 'variations' of what works for their students (p. 750). Teachers need to be encouraged to assess the effectiveness of different theories, and then to modify them for their own classroom settings, students, and subjects.

Cooney (1994),in fact, refers to such process as "pedagogial problem sovling" (p.15). The heart of such pedagogical reasoning (problem sovling) is the process of recognizing the conditions and constraints of the pedagogical problem being faced, determining the context and devising problem solutions based on one's intellectual resources. Helping teachers to gain such "relativist orientation" towards knowledge is an essential dimension of teacher education.

Training

> In order for teachers to choose to teach according to the vision of standards, they must believe that the mathematics and teaching described in the NCTM documents are indeed valuable (Brown & Baird, 1992).

It has been argued that because training is an integral part of preparation for the profession and because it is possible to identify training needs, it becomes incumbent upon teacher preparation units and individuals therein to develop and implement appropriate training regiments (Cruickshank & Metcalf, 1990, p. 473). Some research findings discussed by Cruickshank & Metcalf (1990) include teaching skills in: Changing the deviant behavior of students, the use of discovery teaching, understanding classroom communication, becoming more reflective, and becoming a better problem solver. Their synthesis of research suggest the following as essential principles for training. These are:

1- Establish clear performance goals and communicate them to learners.

2- Insure that learners are aware of the requisite level of skills mastery.

3- Determine learners' present skill level.

4- Introduce only a few basic "rules" during the early learning stages.

5- Build upon learners' present skill level during early learning stages.

6- Ensure during the initial acquisition stage, a basic, essential conceptual understanding of the skill to be learned and when and why it is used.

7- Demonstrate during the initial acquisition stage what final skill performance should look like, drawing attention to salient features of the skill or subskills, as in the case of clarity. Provide sufficient opportunity to learn and apply the feature labels to the demonstration.

8- Provide opportunities for learners to discuss the demonstration.

9- provide sufficient, spaced, skill practice after understanding of all the skill has been developed, in both subskill and cumulative whole skill acquisition.

10- See that practice of skills is followed by knowledge of results.

11- Provide frequent knowledge of results early in the learning process which is more effective if given with less emphasis on response quantity than quality.

12- Provide knowledge of results after incorrect performance of a skill, which is most important.

13- Delay knowledge of results when the learner is beyond the initial stage of learning, which can be as effective as immediate knowledge of results when performance is correct or good.

14- Provide for transfer of training that is enhanced by maximizing similarity between the training and the natural environment, over learning salient features of the skill, providing extensive and varied practice, using delayed feedback, and inducing reflection and occasional testing.

15- provide full support and reinforcement for use of the skills in natural setting.

(Taken form Cruickshank and Metcalf, 1990, p. 474)

The foundation of substantiated methods as found in training research should encourage educators to make use of this system. As Brown, Cooney, and Jones (1990) argued, "Embedded in much of the literature on expert-novice teachers is the implication that some form of training might make the difference" (p. 645). Central to the use of training is the idea that pedagogical skills and reasoning should be explicitly addressed.

Cooney (1994) in a discussion of how to make a pedagogically powerful orientation for training of teachers suggests :

1- enable teachers to develop a knowledge of mathematics that permits the teaching of mathematics form a constructivist perspective;

2- offer occasions for teachers to reflect on their own experiences as learners of mathematics;

3- provide contexts in which teachers develop expertise in identifying and analyzing the constraints they face in teaching and how they can deal with those constraints;

4- furnish contexts in which teachers gain experience in assessing a student's understanding of mathematics;

5- afford opportunities for teachers to translate their knowledge of mathematics into viable teaching strategies (p. 16).

Joyce (1988) claims that training can enable teachers to learn and control pedagogical skills that most novice teachers fail to learn. The system of training described by Joyce combines four components: 1) the study of the theory and research of a teaching skill; 2) demonstrations of the teaching skills; 3) simulated practice of the skill, and 4) self-feedback on skill acquisition. Joyce's second component of systematic training requires demonstration of teaching skills. Rosenshine (1987) also describes modeling in the presentation of new material as:

> Effective teachers elaborate the material by providing many examples, providing additional explanations, making the points explicit and vivid, and summarizing one point before proceeding to the next. When teaching the students a skill, the teacher models each step explicitly (p. 35).

The importance in the modeling of instruction has been realized for some time (Kilpatrick, 1987; Brown & Borko, 1992; Cooney, 1994). Kilpatrick (1987) comments, " Because such art [problem solving and teaching] can be learned only by imitation and practice, teachers need to provide appropriate examples to be imitated followed by opportunities for practice" (p. 94).

Modeling is important in all aspects of teacher education, especially in the cooperating teacher of an internship (Brown & Borko, 1992).

It is only reasonable to assume that modeling the kind of instructional behaviors desired from prosepctive teachers will be the core of the theory of teacher education.

Beliefs

> Teachers' knowledge of mathematics and pedagogy are translated into practice through the filter of their beliefs about mathematics and the nature of mathematics teaching and learning. This underscores the need for a change in the way undergraduate mathematics courses are taught (Swafford, 1995, p. 166)

The issue of receptivity to teacher education has been exploited by a number of researchers. For example, Weinstein (1988) found that pre-service teachers about to begin student teaching expected teaching tasks to be less problematic for themselves than for others. She suggested that pre-service teachers may have an unrealistic optimism about their future teaching performance, and that this optimism may be associated with a lack of motivation to become seriously engaged in teacher preparation. In a study by Book, Byers, and Freeman (1983) 90% of the student group entering professional teacher education studies believed that their professional studies had little new to offer them.

Thompson (1985) reported on different studies that have found little to no change in pre-service teachers' conceptions of mathematics and mathematics teaching after taking courses in methods of teaching. Also, as reported by Lampert (1986), short term studies show that teacher education students can learn the instructional strategies they are taught in their courses, but much of what students learn in their college programs does not survive as usable knowledge beyond the student teaching experience. Bush (1982) found that enculturation was far more of an influencing factor than schooling. It was clear that the pre-service teachers had many well formed beliefs about teaching before they began their formal program in teacher education; tabula roza they were not. He concluded that the teachers identified the methods course as a source for their teaching behaviors when evidence of knowledge of those behaviors was found prior to the methods course. In other word, much of their teaching behavior was rooted in experiences that predated formal teacher education activities (p. 8). Also, Thompson (1984) found that teachers' conceptions of mathematics and mathematics teaching plays a significant role in shaping the teachers' characteristic patterns of instructional behavior.

Beginning teachers often revert to the teaching styles similar to those their own teachers used (Brown, et. al., 1990). Ball (1988) has suggested "that the teacher education programs must sometimes help participants 'unlearn' as well as to learn. Preservice teachers do look to methods

courses for guidance in learning to teach. Many expect a teacher education program to provide a "methods notebook" from which they can find relevant representations and applications for their future instruction (brown, et. al., 1990). Many aspiring mathematics teachers have their beliefs about mathematics changed during a methods course, yet the new view does not always carry over to their teaching practice (Brown & Borko, 1992). Meyerson (1977) found that causing doubt about students' beliefs could often help students analyze those beliefs and bring about change.

Based on these studies as well as other research on preservice teachers' beliefs about teaching (Ball 1991, Cooney 1984, Brown & Baird 1992), it seems reasonable to conclude that because of their prior beliefs, prospective teachers may not see the relevance of their pedagogy courses to the process of learning to teach, and that they may not attend closely to experiences and information offered by those courses. Therefore, any attempt to reform teacher education will need to address the prospective teachers' pre-existing beliefs.

As Cooney (1984) described:

> Despite the fact that all human behavior may contain elements of irrationality, I believe teachers make decisions about students and curriculum in a rational way according to the conceptions they hold. Thus it seems to me that to design teacher education programs without an understanding of those conceptions and the role they play creates a context where we are encouraged to foolishly believe that our insights into the teaching/learning cycle is synonymous or even consistent with those of the teachers we teach (p. 7).

Teachers are influenced by the teaching they see and experience. Prospective teachers must have opportunities in their collegiate courses TO DO MATHEMATICS: explore, analyze, construct models, collect and represent data, present arguments and solve problems. The collegiate level course must reflect the changes in emphasis and content of the emerging school curriculum and rapidly broadening scope of mathematics itself.

Teacher education programs, then, are faced with the problem of teaching prospective teachers think and teach in new ways. They have to challenge participants' preexisting beliefs about the adequacy of their knowledge base for teaching. They will have to help students make their implicit beliefs about teaching, learning, subject matter, and learning to teach explicit; challenge the adequacy of those beliefs; and provide opportunities for students to examine new ideas and integrate new information into their existing belief systems. There is evidence that when preservice teacher preparation courses systematically attempt to challenge preservice teachers' beliefs, changes in those beliefs can and do take place (Ball, 1988; McDiarmid, 1990).

Recently reflection has been identified as a necessary ingredient of change (Laboskey, 1994). One vehicle for reflection is the use of cases in teacher preparation programs (Barnett,

1991; and Merseth, 1991). Action research has also been suggested as another technique for provoking prospective teachers' examination of thier current beliefs (Noffke & Brennan, 1991).

A Self-Evaluation

> Our ability to realize a vision, that is, to change, is largely a function of our ability to be adaptive agents. To be sure, being an adaptive agent in the classroom requires a great deal of knowledge about mathematics, pedagogy and the psychology of learning. But it also requires a certain orientation toward that knowledge. The lenses through which we see our world influence much of what we do. But these lenses are not created out of the abstract; they are context specific. Thus the issue of teacher education becomes immensely complex as we strive to honor what teachers bring to the enterprise while at the same time assist them in becoming adaptive agents in their classrooms (Cooney, 1994, p. 9).

The "empty vessel" metaphor has been used for centuries and in many cultures to describe the essence of teaching and schooling. In this model students' minds are perceived as empty vessels which should be filled with the knowledge dispaired by the teacher. In this view, the activity of the learner is violated, and rote learning and rote teaching is stressed. McKnight et al. (1987) characterized the situation beautifully.

> This use of abstract representations and of strategies geared to rote learning, along with class time devoted to listening to lecture explanations, followed by individual seat work and routine exercises, strongly suggest a view that learning for most students should be passive. Teachers transmit knowledge to students who receive it and remember it mostly in the form in which it was transmitted. This might be considered as an approach of "rote teaching" and "rote learning (p. 81).

This approach has long been challenged and refuted by researchers and educators of many fields of education. Thom (1973), for instance, believes that the role of the teacher at any level of education, is that of a "midwife."

> The teacher is, to bring about a fetus to maturity and, when the moment comes, to free it from the mother structure which engenders it (p. 201).

Also, in constructivist schools, there is the conviction that conceptual knowledge can't be transferred ready made from one person to another, but must be built up by every knower solely

on the basis of his or her own experiences. Within a constructivist interpretation of learning, the transmission model of instruction is not sufficient to generate prospective teachers' understanding about teaching and learning. Although most teacher education programs have been theoretically influenced by these alternative views, their practices do not reflect the essence of these theories. In fact, Thompson (1985) reports on different studies that have found little to no change in pre-service teachers' conceptions of mathematics and mathematics teaching after taking courses in methods of teaching.

As we sit here today and think about the reform movement and what teachers need to be doing, we need to also ask ourselves whether we (the teacher education programs) have realized the importance of nurturing those qualities and standards in our own practice. We need to ask, in particular, what has teacher education programs done to prepare teachers to be active participants in the process of research in learning and teaching? Have teacher education programs been successful in providing teachers with sufficient background both in content and methodology, as well as the research theories in order to make their presence current and more effective? Are teacher education programs developing a cultural context for students to enter the world of practice by standards, and research? Have teacher education programs in Bausersfiels (1978) words, "developed their own self-concept?"

A look at the research on teacher education reveals startling findings. The observations made on the activities of the teacher education programs have raised serious concerns about the adequacy of their operation.

> In a typical mathematics teacher education program much time is spent on discussing the components of an ideal mathematics program. In fact, prospective teachers often are exposed to results of many studies of children's understanding of mathematics. Most of this work, however, is done through lectures, or reading. In any of these situations the teacher educator is assuming that the ideas being transmitted are being assimilated by future teachers. Furthermore, it is assumed that once these ideas are assimilated or "learned," they will easily be incorporated into the teacher's actual teaching of school mathematics" (D'Ambrosio & Campos Mendonca, 1992; p. 213).

According to Gage (1978) "much of the teacher education program is given over to providing teachers with great deal of knowledge that certain things are true, in the subject (and grade levels) to be taught" (p.4).
Cooney (1992), in recognizing the problem of such practice in mathematics teacher education, declared:

> Unfortunately, we too often neglected our epistemological framework and engaged in the process of conveying our models to teachers. The models for teaching and learning had the academic stamp of approval by being research based. But be not mistaken, the operative word is that of conveying, that is, of giving (p.5).

It appears that teacher education programs have, for the most part, fallen short in providing adequate and appropriate experience and knowledge for their students. What teacher education programs are implementing today are simply derivatives of the old and somewhat obsolete methods of instruction. Therefore, inspite the fact that the attempt has been made to improve the circumstance of the programs, changes have been of no significant substance. The relatively minor adjustments of the past have proven to be almost completely futile. There is more that needs to be done than to rearrange or retile the same old courses, methods and program.

Content and Pedagoy: Conceptual understanding

Teacher education has, almost since its conception, rested on the assumption that subject matter and pedagogy are separate bodies of knowledge: They can be thought about, taught, and learned separately. Although this assumption is present in the teacher education at all levels, it is even more apparent at the secondary teacher education programs. Such separation, however, causes variety of serious problems since the mathematics instruction that majority of perspective teachers experience, are derivatives of the traditional method that is typically algorithmic in nature and lecture oriented. Their experiences generally consist of highly structured situations in which the students are passive listeners trying to assimilate as much of what is being transmitted as possible. Consequently, their beliefs and conceptions of mathematics learning and teaching are shaped by those experiences.

In mathemaics classrooms of a large number of universities and colleges the presentation of ideas through lecture has not been replaced by a repertoire of instructional strategies that include a greater number of powerful representations, explorations and investigations. Technology is not introduced or integrated in instruction. Students experience "knowledge" as a collection of disconnected facts which would be applied to problems according to the classroom setting. Alternative methods of assessment are either completely ignored, or not given sufficient attention . Letter grades are still being prostituted solely on the basis of performance on the written examinations. Less attention has been focused on individual creativity and original thinking. The goal of most students is not to become prepared for the future profession, but to strive for a better grade in the course.

Prospective teachers must be given the opportunity in their university course work to strengthen their content knowledge and pedagogical content knowledge. One area worthy of

attention is the development of representations and representational contexts that will enable them to draw connections between concepts and applications, on the one hand, and algorithms and procedures on the other. Teacher education programs must provide time to encourage the kind of practice and reflection necessary for the development of these components of the perspective teachers' professional knowledge base. These aspects, according to Brown and Borko (1992), have not yet become a reality in mathematics teacher education programs.

> [N]either current academic nor current professional educational coursework are particularly good at helping prospective teachers develop high literacy in their content areas... improvements in both should be the focus of teacher education reforms (Brown & Borko, 1992, p. 221).

Modeling and Training

Teacher education programs need to participate much more actively in the assigning of the student teachers to classroom teachers in schools selected. It seems rather ironic that we submit our student teachers to the same kind of practice that we want teacher education programs to change. Teacher education programs must join with the districts in improving the quality of education at all levels. They must participate in design and implementing inservice programs. They must make themselves accessible to teachers who are not prepared to implement the suggested reforms in school curriculum. Such commitment should get teachers involved through active participation in school activities, communicating with them through and along with student teachers, and sharing their experiences with the school faculty.

It seems that the high expectations for research in many universities has tended to work against a commitment to teacher education by professors in the schools of education (Goodlad, 1976; Bishop, 1992). I do believe however that the two are not, and should not be mutually exclusive. If the aim of research is to improve the circumstances of teaching and learning, involving teachers in the process of research can bridge the gap, which has historically existed, between researchers and practitioners in education. Action research provides a means for teachers to claim ownership of the findings, and also serves the purpose of educational research. It is clear that teacher preparation programs can greatly benefit from direct collaboration and communication with practicing teachers.

Closing Comments

What is proposed in this paper, is the urgency of the need for a theory of reform. A theory for shaping the core of teacher education programs and their ways of operating. The instruction of aspiring teachers lacks theory as described in this review of literature.

For hundreds of years, succeeding generation of people have agreed on the importance of education, but have disagreed over what it should be, and how it should be organized. There is no shortage of critics and reform. Advocates of educational reform have existed for so long that it is impossible to identify the first one. In our written records, there is considerable evidence to use education to alter society, and thus the recognition that divergent ideas about education can be very controversial. One of the two accusations leveled against Socrates, was "corruption of the young." He may have paid the ultimate price for being an educational reformer in a political setting that was not ready for reforms.

We know of Socrates through the writings of Plato, who also identified education as a central element in establishing and maintaining a good society. Lawrence Cremin (1965) considers Plato's Republic:

> The most penetrating analysis of education and politics ever undertaken. Plato's argument: In order to talk about a good life we have to talk about a good society, we have to talk about the kind of education that will bring the society into existence and sustain it (p. 4).

In modern days, if we talk of providing "good life" for students in schools, we need to equally talk of the "good society" which gives life and existence to it. Teacher education programs are the "societies" which need to redefine their concept of "good life," and seriously reconsider their vital role in sustaining "good living."

It is essential for teacher education programs to examine their state and look even more carefully at their weaknesses. Teacher education programs will need to create a community in which messages and forces are consistent and compatible with the vision of teaching being promoted.

1.

Kilpatrick (1992) identified research as "disciplined inquiry." He elaborated:

> The term inquiry suggests that the work is aimed at answering a specific question, it is not idle speculation or scholarship for its own sake. The term discipline suggests not only that the investigation may be guided by concepts and methods from disciplines such as psychology, history, philosophy, or anthropology but also that it is put on display so that the line of inquiry can be examined and verified. Disciplined inquiry need not be scientific in the sense of being based on empirically tested hypothesis, but like any good scientific work, it ought to be scholory, public, and open to critique and possible refutation. Research in mathematics education, then, is disciplined inquiry into the teaching and learning of mathematics (p. 3).

Similarly, Bishop (1992) took the view that to qualify as research (in mathematics education), a study needs three components:

> ***Enquiry***, which concerns the reason for the research activity. It represents the systematic quest for knowledge, the search for understanding, and gives the dynamism to the activity. Research must be intentional inquiry.
> ***Evidence***, which is necessary in order to keep the research related to the reality of the mathematical education situation under study, be it classrooms, syllabuses, textbooks, or historical documents. Evidence samples the reality on which the theorizing is focused.
> ***Theory***, which recognizes the existence of values, assumptions, and generalized relationships. It is the way in which we represent the knowledge and understanding that comes from any particular research study. Theory is the essential product of the research activity, and theorizing is, therefore, its essential goal (p. 712).

In this paper, research has been identified to be the inquiry consistent with the guidelines identified by Kilpatrick (1992) and Bishop (1992).

References:

Adler, M. (1982). The paideia proposal. New York: Macmillan.

Ball, D. L. (1988a). Unlearning to teach mathematics. For the Learning of Mathematics, 8(1), 40-48.

Ball, D. L. (1988b). Research on teacher learning: Studying how teachers' knowledge changes. Action in Teacher Education, 10(2), 17-24.

Ball, D. L. (1990). Prospective elementary and secondary teachers' understanding of division. Journal for research in Mathematics Education, 21, 132-144.

Barnett, C. (1991). Building a case based curriculum to enhance the pedagogical content knowledge of mathematics teachers. Journal of Teacher Education, 42(2), 1-9.

Bausersfeld, H. (1978). Research related to the mathematical learning process. New Trends in Mathematics, 4(3), 15-46.

Begle, E. G. (1970). Critical variables in mathematics education: Findings from a survey of empirical literature. Washington, D.C.: Mathematical Association of America and National Council of Teachers of Mathematics.

Bishop, A. (1992).International perspectives on research in mathematics education. In Grouws, D. A. (Ed.) Handbook of research on mathematics teaching and learning (pp. 710-723). New York: Macmillan.

Board, M. S. E. (1986). A paper issued by the National Research Council. Washington, DC.

Book, C., Byers, J., & Freeman, D. (1983). Student expectations and teacher education traditions with which we can and cannot live. Journal of Teacher Education, 34(1), 9-13.

Brown, C. A., & Baird, J. (1992). Inside the teacher: Knowledge, beliefs and attitudes.

Brown, C. A., & Borko, H. (1992). Becoming a mathematics teacher. In D. Grouws (Ed.), Handbook of Research on Mathematics Teaching and Learning (pp. 209-239). New York: Macmillan.

Brown, C. A. , & Cooney, T. J. (1985). The importance of meanings and milieu in developing theories on teaching mathematics. Paper presented at the conference on "Theory in Mathematics Education", Bielefeld, Federal Republic of Germany.

Brown, S. Cooney, T., and Jones, D. (1990). Mathematics teacher education. In W. R. Houston (Ed.), Handbook of research on teacher education (pp. 469-497). New York: Macmillan.

Bush, W. (1986). Preservice teachers' sources of decisions in teaching secondary mathematics. Journal for Research in Mathematics Education, 17(1), 21-30.

Cooney, T. J. (1992). Ultimate epistemologies in teacher education. Paper presented at the international conference on the Ultimate Epistemologies in Education. Athens, GA.

Cooney, T. C. (1994). Teacher education as an exercise in adaptation. In D. B. Aichele & A. F. Coxford (Eds.). Professional development for teachers of mathematics, 1994 Yearbook (pp. 9-22). Reston, VA: National Council of Teachers of Mathematics.

Cremin, L. (1965). The Genius of American Education. New York: Random House.

Cruickshank, D., & Metcalf, K. (1990). Training within teacher preparation. In W. R. Houston (Ed.), Handbook of research on teacher education (pp. 469-497). New York: Macmillan.

D'Ambrosio, B. S., and Campos Mendonca, T. M. (1992). Pre-Service teachers' representations of children's understanding of mathematical concepts: Conflict and conflict resolutions. Educational Studies in Mathematics, 23, 213-230.

Enderson, M. C. (1995). Assessment practices of three preservice secondary mathematics teachers. An unpublished doctoral dissertation, The University of Georgia, Athens.

Eisenhart, M. A. (1988). The ethnographic research tradition and mathematics education research. Journal for Research in Mathematics Education(19), 99-114.

Feiman-Nemser, S. & Buchmann, M. (1986). The first year of teacher preparation: Transition to Pedagogical thinking? Journal of Curricular Studies, 18, 239-256.

Fuller, F., & Brown, O. (1975). On becoming a teacher. In K. Ryan (Ed.), teacher education (The 74th yearbook of the National Society of the study of Education, pp. 25-52). Chicago, IL: University of Chicago Press.

Gage, N. L. (1978). The scientific basis of the art of teaching. New York: Teachers College Press.

Gage, N. L. (1963). Paradigms for research on teaching.

Goodlad, J. I. (1984). A place called school: Prospects for the future. New York: McGraw Hill.

Grossman, P. (1988). A study in contrast: Sources of pedagogical content knowledge. Educational Researcher, 18, 21-56.

Hammond, L. D. (1984). Beyond the commission report: The coming crisis in teaching. Santa Monica, CA: The Rand Corporation.

Howe, H. (1982). Improving teaching: Solutions close to the classroom. College Board Review, 12(15), 28-29.

Joyce, B. (1988). Training research and preservice teacher education: A reconsideration. Journal of Teacher Education, 39(5), 32-36.

Kilpatrick, J. (1977). The psychology of learning in mathematical education. In International federation for information processing working conference on information and mathematics in secondary schools: Impacts and Relationships. Varna, Bulgaria.

Kilpatrick, J. (1978). Change and stability in research in mathematics education. Zentrallblat fur Didaktik der Mathematik, 88(5), 202-204.

Kilpatrick, J. (1987). Is teaching teachable? George Polya's views on the training of mathematics teachers. In F. Curcio (Ed.), Teaching and Learning: A problem solving focus (pp. 85-97). Reston, VA: National Council of Teachers of Mathematics.

Kilpatrick, J. (1992). A history of research in mathematics education. In Grouws, D. A. (Ed.) Handbook of research on mathematics teaching and learning (pp. 3-48). New York: Macmillan.

LaBosky, V. K. (1994). Development of reflective practice: A study of preservice teachers. New York: Teachers College press.

Lampert, M. (1986). What can research on teacher education tell us about Improving quality in mathematics education? Harvard Educational Review, 55, 178-194.

McDiarmid, G. W. (1990). Challenging prospective teachers' beliefs during early field experience: A quixotic undertaking? Journal of Teacher Education, 41(3), 12-20.

Merseth, K. K. (1991). The case for cases in teacher education. Washington, D.C.: American Association of Colleges for Teacher education and American Association for Higher Education.

National Council of Teachers of Mathematics, (1982). An Agenda for Action: Recommendations for School Mathematics of the 1980s. Reston, VA: NCTM.

National Council of Teachers of Mathematics, (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: NCTM.

National Council of Teachers of Mathematics, (1991). Professional standards for teaching mathematics. Reston, VA: NCTM.

National Council of Teachers of Mathematics, (1995). Assessment standards for teaching mathematics. Reston, VA: NCTM.

National Commission on Excellence in Education. (1983). A nation at risk. Washington D.C. : U. S. Department of Education.

Rosenshine, B. (1987). Explicit teacher and teacher training. Journal of Teacher Education, 38(3), 34-36.

Shulman, L. E. (1978). Strategic sites for research on teaching. Invited address for Special Interest Group (SIG) in mathematics education. AERA annual meeting.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15, 4-14.

Shulman, L., & Grossman, P. (1988). Knowledge growth in teaching: A final report to the spencer Foundation. Stanford, CA: Stanford University.

Swafford, J. O. (1995). Teacher Preparation. In Iris M. Carl (Ed.), Prospects for school mathematics (pp.157-174). Reston, VA: National Council of Teachers of Mathematics.

Teachers, T. (1986). A report of the Holmes Group. East Lansing: The University of Michigan.

Thompson, A. (1985). Teachers' conceptions of mathematics and the teaching of problem solving. In E. A. Silver (Ed.), Teaching and learning of mathematical problem solving: Multiple research perspectives. Hillsdale, NJ: Lawrence Erlbaum Associates. pp. 281-294.

Wilson, J. W., & Kilpatrick, J. (1984). Taking mathematics teaching seriously: Reflections on the teacher shortage. In J. L. Taylor (Eds.), Teacher shortage in science and mathematics: Myths, realities, and research Washington, D.C.: National Institute of Education.